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Mass-length relationships of spiders and harvestmen (Araneae and Opiliones)

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Mass-length relationships of spiders and harvestmen (Araneae and Opiliones). - General relationships of dry mass vs. length are derived for spiders (Araneae, 7 families, 11 species) and harvestmen (Opiliones, 1 family, 4 species) found along a water shore in southern Germany. The spider equation encompasses previous species-specific and habitat-specific estimates and should thus be of general applicability for spiders < 10 mm in length. The harvestman equation is applicable to harvestmen with a normal rotund, oval-cylindrical body shape. Our equations are useful to estimate the biomass of spiders and harvestmen, which is important to elucidate trophic relationships, productivity and population dynamics in community ecology.

Key-words: mass-length relationship – biomass – trophic relationships – population dynamics.

INTRODUCTION

Biomass data are useful to analyze ecological relationships in food webs. The biomass of insects (prey, competitors or predators of spiders) can be conveniently estimated with the general mass-length relationship given by ROGERS *et al.* (1976). However, no such general relationships have been established for arachnids.

Different mass-length relationships given for each of ten spider species by BREYMEYER (1967) and CLAUSEN (1983) do not enable biomass estimates to be made for spiders in general. The authors caution that the regression lines differ significantly among most species and should be determined independently for each. This is daunting for studies involving many species. By contrast, general relationships are often sufficient to compare biomass at different sites.

Here we develop such general mass-length relationships for spiders (Araneae) and harvestmen (Opiliones) captured along a river shore in Germany. The spider species varied in body shape from elongate cylindrical to globular round and broad flattish; the harvestmen were rotund cylindrical to oval. We test the generality of our spider equation by comparing it with previous estimates.

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METHODS

Spiders and harvestmen of various sizes, ages and sexes were captured between June–October 1994 in a 8 ha riparian forest along the Main River in Würzburg, Bavaria, southern Germany.

Total length was measured with a graduated eyepiece (± 0.01 mm; dorsal, anterior edge of prosoma to posterior edge of opisthosoma; excluding chelicerae and spinnerets). The following 138 spiders, including members of both sexes, were measured (adult species are given in brackets for genera where immatures were indistinct; species names follow PLATEN *et al.* 1995): Clubionidae: 27 *Clubiona* sp. (*C. lutescens* Westring and *C. phragmitis* C.L. Koch); Linyphiidae: 27 *Gongylidium rufipes* (Linnaeus); Tetragnathidae: 22 *Tetragnatha* sp. (*T. montana* Simon) and 6 *Pachygnatha clercki* Sundevall; Philodromidae: 14 *Philodromus* sp.; Araneidae: 14 *Singa hamata* (Clerck), 11 *Larinioides cornutus* (Clerck), 9 *Araniella* sp. (*A. opisthographa* (Kulczynski)); Dictynidae: 4 *Dictyna* sp.; Theridiidae: 4 *Theridion* sp. (*T. bimaculatum* (Linnaeus)). The 53 Phalangiidae (Opiliones) measured were: 23 *Opilio canestrinii* (Thorell), 23 *Oligolophus tridens* (C.L. Koch), 4 *Leiobunum rotundum* (Latreille) and 3 *Rilaena triangularis* (Herbst). Measured specimens were oven-dried at 110°C for 1 d and 65°C for 1 d, then cooled to room temperature and weighed (± 0.01 mg; Mettler MT5 scale). Many harvestmen were not intact due to loss of legs during life or capture. All harvestmen were therefore weighed without any legs; for 14, a set of four legs was weighed and multiplied by two to determine leg mass relative to the body.

RESULTS

The equation for all 138 spiders is (Fig. 1a):

$$M = 0.076L^{2.245} \quad (1)$$

where M is dry mass in mg and L is length in mm ($r^2 = 0.88$; $P < 0.001$; d.f. = 136; s.e. of coefficient = 0.024; s.e. of exponent = 0.071). The equations were not significantly different ($P > 0.05$) between *Clubiona* sp., *Philodromus* sp., *Tetragnatha* sp. and *Singa hamata*. The slope was significantly steeper for *Larinioides cornutus* than for other spiders ($t > 2.7$; $P < 0.05$) and shallower for *Gongylidium rufipes* ($t > 3.0$; $P < 0.05$).

The equation for the 53 harvestmen (without legs) is (Fig. 1b):

$$M = 0.058L^{2.559} \quad (2)$$

($r^2 = 0.92$; $P < 0.001$; d.f. = 51; s.e. of coefficient = 0.012; s.e. of exponent = 0.104). The slopes differed significantly between *Oligolophus tridens* and *Opilio canestrinii* ($t = 2.92$; d.f. = 43; $P < 0.05$). Eight legs of *O. tridens* represent 28.9% of the total mass of body and legs (SD = 4.9%; n = 5); for *O. canestrinii* it was 40.0% (SD = 6.3%; n = 9). With legs, the coefficient of the equation becomes 0.050 ±se 0.012 and the exponent 2.962 ±se 0.402 ($r^2 = 0.82$; $P < 0.001$; d.f. = 12). We suggest that equation 2 be used as a conservative estimate, because of the variable number of legs naturally found on harvestmen due to leg loss.

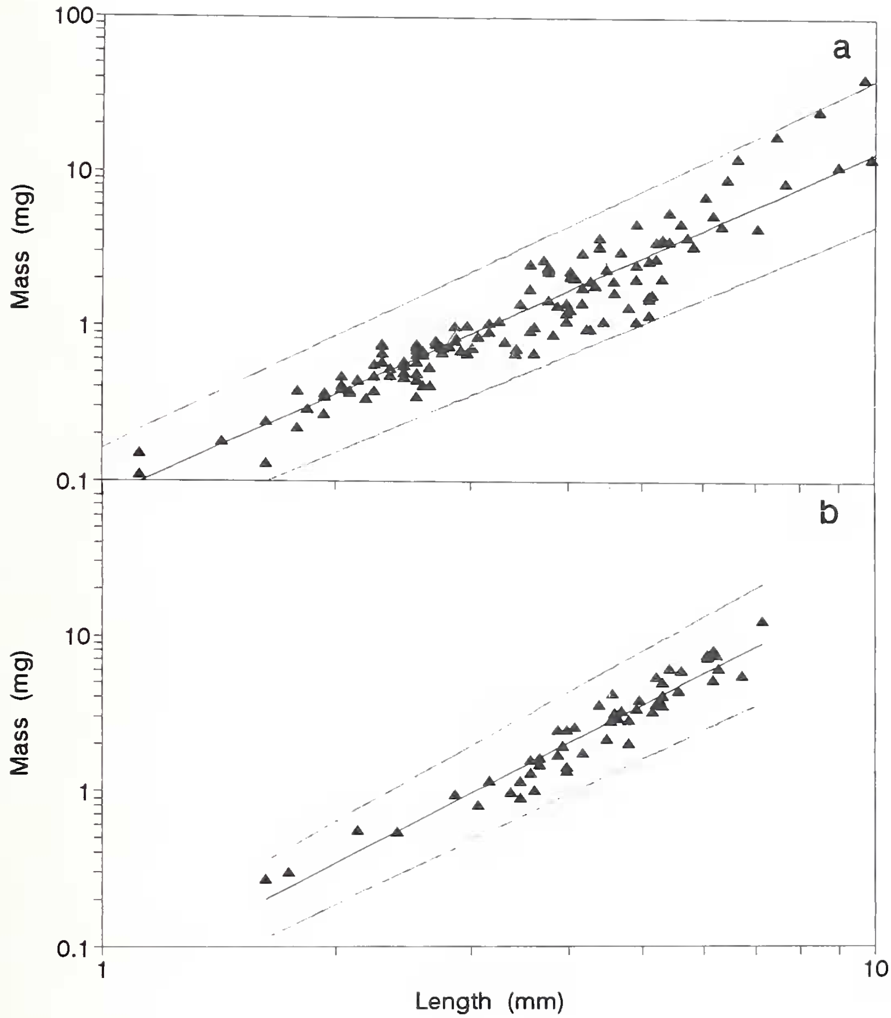

FIG. 1

Log-log plots of the dry mass vs. length relationship ± 95% confidence limits of (a) spiders (138 individuals of 11 species from 7 families) and (b) harvestmen (53 individuals of 4 species of Phalangiidae).

DISCUSSION

Community ecologists typically deal with species-rich samples that are often obtained with inherently imprecise, albeit consistent, methods (e.g. HENSCHEL *et al.* 1996). In view of this, it would appear superfluous and impractical to apply precise mass-length relationships for each species. We suggest that general equations for spiders and harvestmen are more useful for estimating biomass in community studies than many specific equations are.

Our general equation for spiders from one shore site should not only be applicable for studies of Bavarian shores. It appears to be broadly similar to estimates for particular spider species from other regions and habitats in Europe. The end-points of all but one of the species-specific equations given by BREYMEYER (1967) and CLAUSEN (1983) fall within the confidence limits of our relationship (Fig. 1a); the slight outlier is CLAUSEN's (1983) maximum mass of *Nuctenea umbratica* (*sub Araneus umbraticus*). Clausen's other curves were situated to the right of our curve, probably because he included the changeable chelicerae and spinnerets in his measurements of length whereas we did not.

Further evidence for the general applicability of our spider equation comes from NORBERG's (1978) determination of fresh mass versus length of 496 arboreal spiders of 18 species in Sweden. When the intercept is adjusted to 37.9% dry mass given by NORBERG (1978), his curve falls very close to ours (< 0.18 standard errors). Our general spider equation thus encompasses at least the following families (BREYMEYER 1967; NORBERG 1978; CLAUSEN 1983; present study): Araneidae, Agelenidae, Clubionidae, Dictynidae, Linyphiidae, Lycosidae, Philodromidae, Segestriidae, Tetragnathidae, Theridiidae, Thomisidae and Uloboridae.

To our knowledge, we are the first to derive a mass-length relationship for harvestmen, so that comparisons cannot be made. Although all our Opiliones were from only one family, we do not expect the relationship to differ much in other families. Harvestmen in general are not as diverse in shape as spiders or insects are.

In concluding that our equations appear to be of general applicability in community studies, we should point out their limitations. They have been derived only from spiders and harvestmen smaller than 10 mm in length and may not apply to larger arachnids. Our relatively wide error margins may be unsatisfactory for studies involving only a specific family, genus or species, where mass-length relationships should be determined separately (A. Lang, pers. comm.). The application of the general equations by HENSCHEL *et al.* (1996) illustrates their value.

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